CHAPTER -3

DIMENSIONS OF THE OCEANS

1.1: Shape and Size of the oceans:

Our concept of the earth's shape has changed over the years. The idea that the earth is a sphere was modified when scientists realized that the earth is flattened slightly at the poles. That is it has nearly the shape of an oblate spheroid. This shape is the one assumed by a rotating body with equilibrium between gravitational and rotational (centrifugal) forces. The flattening causes the polar radius to be 22 km shorter than the equatorial radius.

With the advent of space exploration, scientists were able to examine the earth's shape from the space satellites. Their observations led to the conclusion that the shape of the earth is really that of an irregular fat pear. Ultimately all our ideas have to be changed as more information came about earth. Now that it is clear that earth has a unique shape of its own (Spheroid), unlike any regular known geometric figures. A spheroid looks like a sphere but it doesn't have a uniform radius but a variable radius like an ellipsoid.

1.1.1: Table of Earth Dimensions;

Dimension	Magnitude	Units
Mass	6×10^{27}	Kg
Volume	1.1×10^{12}	Km^3
Circumference	40×10^{3}	Km
Poar Radius	6,356	Km
Equitorial Radius	6,378	Km
Total Surface Area	510×10^{6}	Km^2
Land Surface Area	149×10^{6}	Km^2
Ocean Surface Area	361×10^{6}	Km^2
Ocean Volume	$1,370\times10^{6}$	Km^3
Ocean Average depth	3,795	meters

While about 71% of the earth's surface is covered by a film of water that fills a system of basin called Oceans, nearly 98% of the water on the earth's surface is in the oceans. These dimensions are not constant because of the variations in sea level.

If all the water (1370 million) is spread uniformly over the surface of the earth (510 million) the mean height of water level would be approximately 2.7 km. This height is called the geoid. This corresponds to the pressure of 270 kg wt cm^{-2}, if the atmospheric pressure is approximately 1 kg wt cm^{-2}.This means the mass of the oceans is 270 times that of the atmosphere.

The mean depth of the oceans is the ratio of the volume of the oceans (1370 million) to the area of the ocean basins (361 million), which is equal to 3.8 km. Which means the mean depth of the oceans is 1/1675 times of the mean radius of the earth. This in turn implies Oceans constitute only a very thin layer on the surface of the earth. Thus the earth and the oceans can be viewed as a date- palm fruit such that the center seed of this date-palm fruit is the core, the flesh is the mantle and the skin is the crust of the ocean & land.

1.1.2. Ocean & Land Distribution:

The oceans are the basins on the surface of the earth with salt water filled in it. The major oceans are The Atlantic, the Pacific, the Indian, the Arctic and the Southern ocean. The first four are clearly divided from each other by land masses but the divisions between the Southern ocean and the others to its north are determined only by the characteristics of ocean waters and by their circulation. Then there are smaller bodies of water called seas. The landlocked seas are the Mediterranean, the Bearing, and the South China Sea etc. There are seas within the ocean also like Sargasso Sea, Caribbean Sea etc. These oceanic seas are distinguished due to the variation of physical properties of water like color, nutrients and circulation.

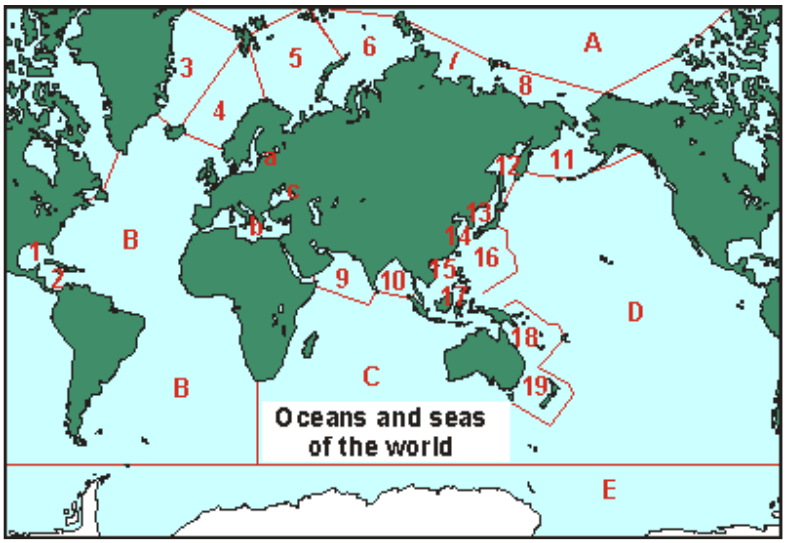
Looking at the globe the more of the earth's surface is covered by the sea than by land, i.e. about 71% compared to 29 %(Fig.3.1a). Further more the proportion of water to land in the Southern Hemisphere is more (4:1) than the Northern Hemisphere (1.5:1).In area the Pacific Ocean is as large as the combined area of the Atlantic and the Indian Ocean. While the Pacific Ocean is nearly 46% of the total world oceans, the Atlantic and the Indian Ocean respectively are 23% and 20%. The remaining seas and oceans are 11% of the world oceans. The detailed dimensions of each of the major oceans are as below.

The view of the world that includes most of the land still contains a large share of the oceans. In this part of the globe, live over 90% of all people. It is also where most environmental problems are felt. In the centre one sees the Atlantic Ocean and east of Africa the Indian Ocean, looking much smaller due to the curvature of the globe.

The view of the water world contains very little land and few people. The main continents of North and South America and Asia, are just visible around the edges. New Zealand is the continent that lies closest to the centre of the water world, the Pacific Ocean. West of Australia the Indian Ocean.

Ocean basin		Area ($10^6 Km^2$)	Volume($10^6 Km^2$)	Mean depth (m)
Atlantic	Excluding Adjacent seas	82.4	323.6	3926
Indian		73.4	291.0	3963
Pacific Ocean		165.2	707.5	4282
Arctic		14.0	16.9	1205
Antarctic		32.0	120.0	
Atlantic	Including Adjacent seas	106.4	354.6	3332
Indian		74.9	291.9	3897
Pacific Ocean		179.6	723.7	4028

Oceans A Arctic Ocean B Atlantic Ocean C Indian Ocean D Pacific Ocean E Southern Ocean * **Enclosed or almost enclosed seas** a Baltic Sea b Mediterranean Sea c Black Sea d Red Sea e Persian Gulf f Gulf of Oman **Large coastal seas** 1 Gulf of Mexico 2 Caribbean Sea 3 Greenland Sea	4 Norwegian Sea 5 Barents Sea 6 Kara Sea 7 Laptev Sea 8 East Siberian Sea 9 Arabian Sea 10 Bay of Bengal 11 Bering Sea 12 Sea of Okhotsk 13 Sea of Japan 14 East China Sea 15 South China Sea 16 Philippine Sea 17 Indonesian Archipelago 18 Coral Sea 19 Tasman Sea 20 North Sea



While the average depth of the oceans is close to 4000 meters, the seas are generally 1200 m are so. Relative to sea level the oceans are much deeper than the land is high. While only 11% of the land is more than 2000meters above sea level, nearly 84% of the sea bottom is more than 2000 m deep. For example, while the highest peak on the surface of the earth, the Mount Everest, is 8840 meters, the deepest trench, the Mindanao trench in Mariana's region of the Pacific is

11,524 meters. Compared to the horizontal dimensions of the oceans (5000 to 15000 Km), the vertical dimensions (4 km) are very small.

Figure 3.1(a) shows the hypsographic curve of the earth's surface, showing how the surface area of the globe is distributed. The abscissa shows the total percentage area in land and oceans and the ordinate shows the depth or height in the oceans or land respectively. Please note that while the average height on land is 840 m the average depth in the oceans is 3795 m. Fig.3.1(b) is the histogram showing the percentages for each 1000m height or depth interval. The continental shelf to 200 m below sea level in the oceans represents 5.3%. However the detailed distribution is given in table 3.1

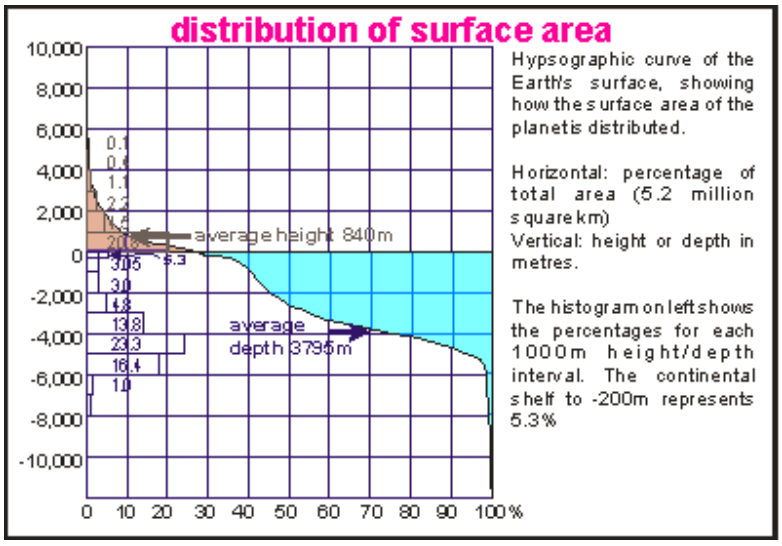


Fig.3.1(a).distribution of surface area on the globe

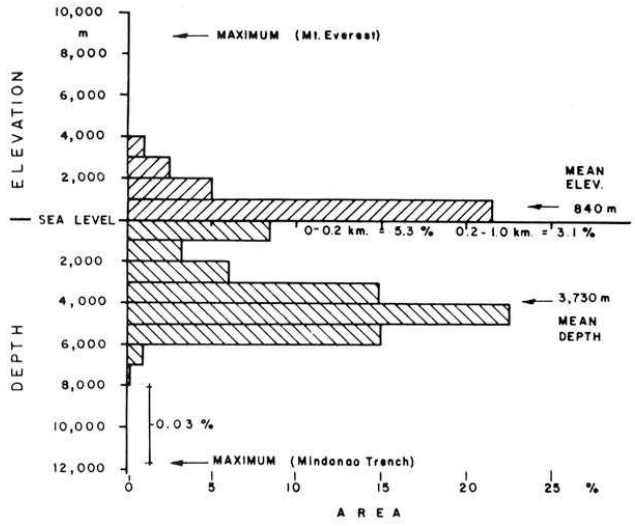


Fig.3.1(b) Percentage area coverage of elevations and depths with respect to MSL

Table 3.1. The depth distribution in the oceans is as below:

Depth (Km)	Common name	Percentage of the total area of the oceans	
0 – 0.2 km	Continental shelf	7.6%	11.9%
0.2 – 1.0 km	Continental shelf	4.3%	
1 – 2 km	Continental slope	4.2%	11.0%
2 – 3 km	Continental slope	6.8%	
3 – 4 km	Abyssal Plain	19.6%	76.9%
4 – 5 km	Abyssal Plain	33.0%	
5 – 6 km	Abyssal Plain	23.3%	
6 – 7 km	Abyssal Plain	1.0%	
> 7 km	Trench	0.2%	0.2%

Main ocean trenches are shown in Fig.3.1c. They are (a) Aleutian, (b) Kuril, (c) Japan, (d) Mariana, (e) Philippine, (f) Java, (g) Tonga Kermadec, (h) Peru-Chile.

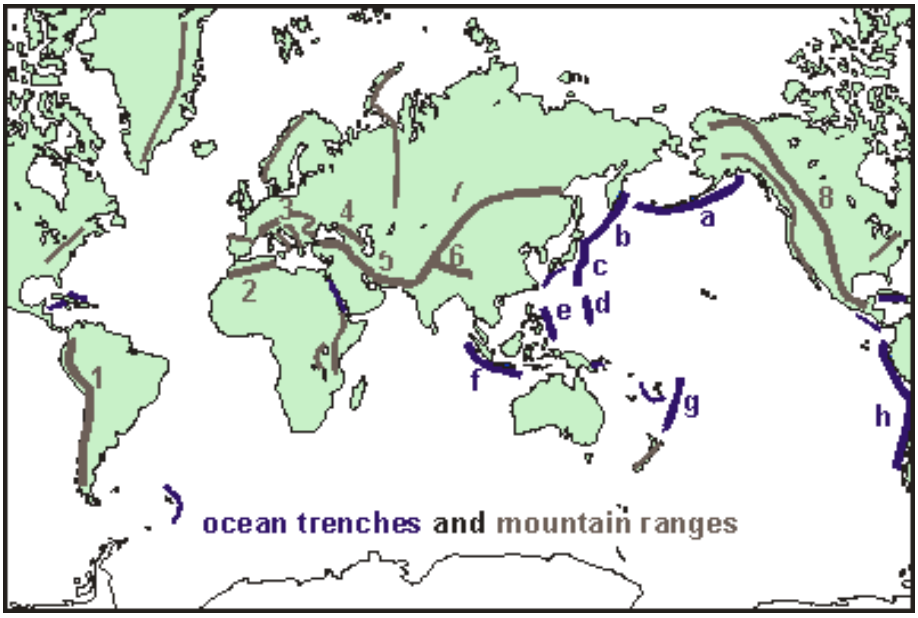


Fig.3.1c: Distribution of different trenches (blue markings) in the oceans. Grey markings are mountain ranges

The ocean-floor looks very much like our land. It has soaring mountains, plunging valleys and rolling plains (Fig.3.2 a, b, c, d&3.3). There are mountain chains that are mightier than the Himalayas, called the mid-oceanic ridges, which run in the middle of all the major oceans (Fig.3.2a) for a total length of about 74,000 km. Mid oceanic ridges are centers of sea-floor spreading where new ocean crust is created by outpouring of lava. This new crust continuously spreads away from the mid-oceanic ridges - something like a conveyor belt! Finally the oceanic crust descends or gets pushed down into deep trenches which are about 3 to 6 km deeper than the adjacent sea-floor (see figure above). This is how the destruction of oceanic crust occurs. All along the trenches, lava comes out at temperatures of above 800^{o} to 1000^{o} C and builds up a chain of volcanic islands (along landward side), followed by frequent earthquakes.

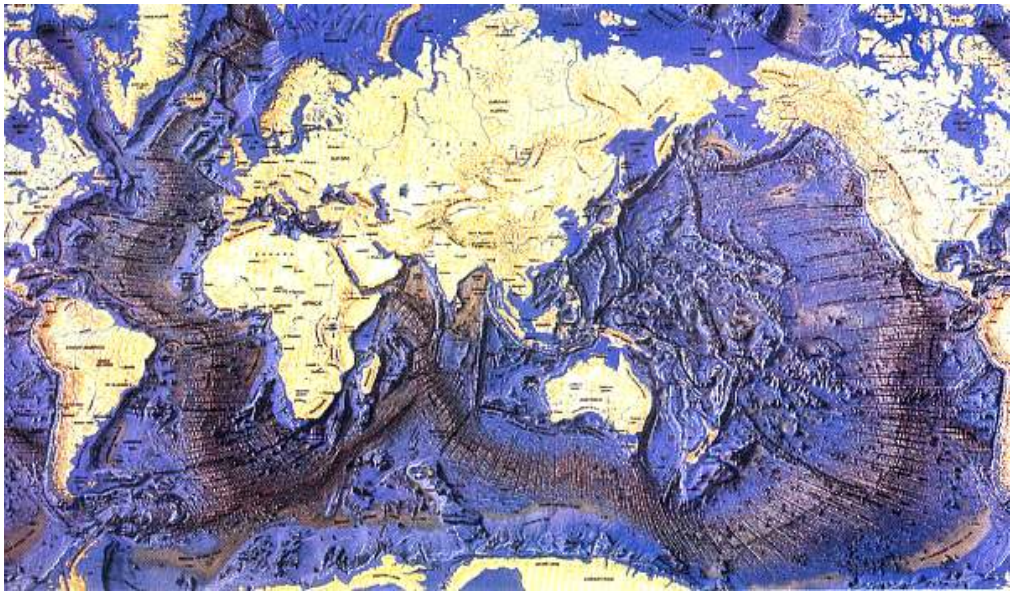


Fig.3.2a:The ocean's floor, painstakingly mapped by Bruce Heezen and Marie Tharp, just after World WarII. The spreading zones can clearly be distinguished from the subduction zones with their trenches.

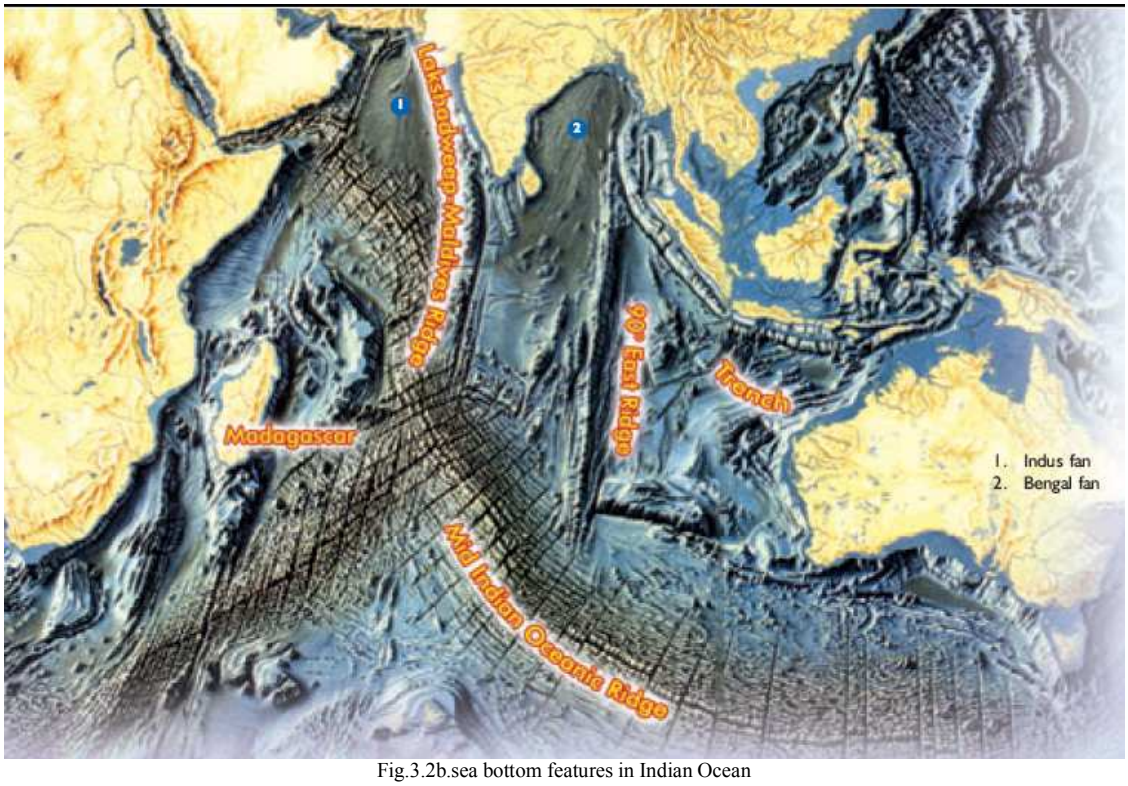


Fig.3.2b.sea bottom features in Indian Ocean

It is interesting to note that in the Bay of Bengal, there is a huge fan called "Bengal Fan" (Fig.3.2b) which is made up of sediments brought in by the Ganges and Brahmaputra rivers. This is considered to extend for nearly 3000 km with a maximum width of about 1400 km. Similarly, the Arabian Sea is fed by voluminous sediments by the mighty Indus river draining the Himalayan ranges. The sediment thickness exceeds 10 km and covers nearly 1500 km in length with a width of about 960 km. This beautiful structure in the Arabian Sea is known as "Indus Fan".

The actual features of the topography of the Indian Ocean are as shown by the satellite photo in Figure 3.2c and the description of each of the feature is shown in figure 3.2d.

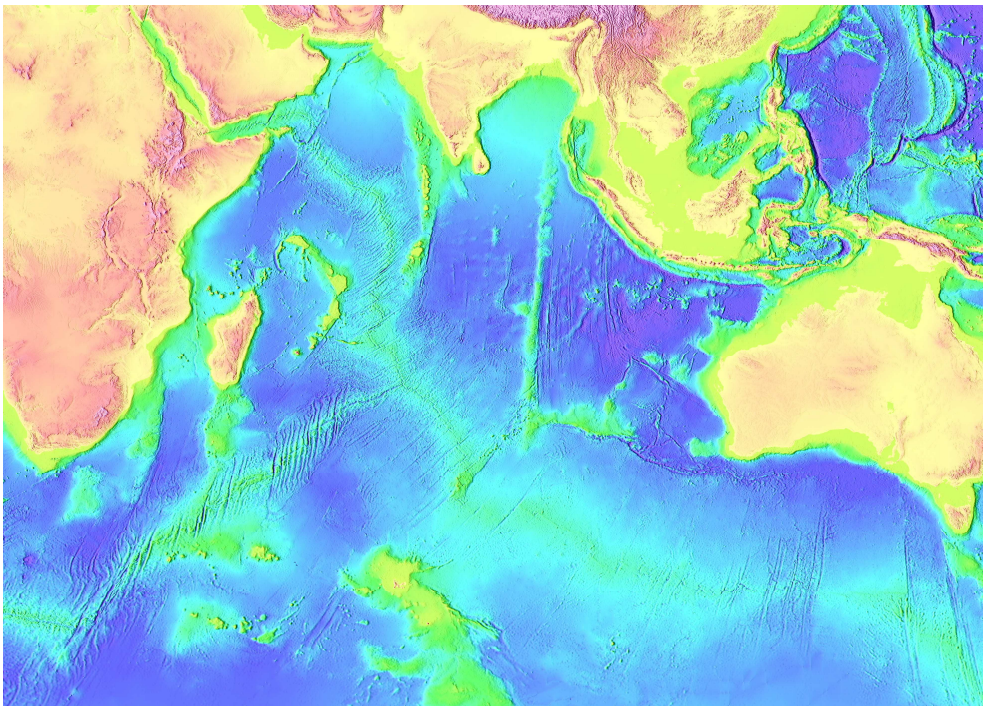


Fig.3.2c Different features in Indian Ocean as depicted by a satellite photo

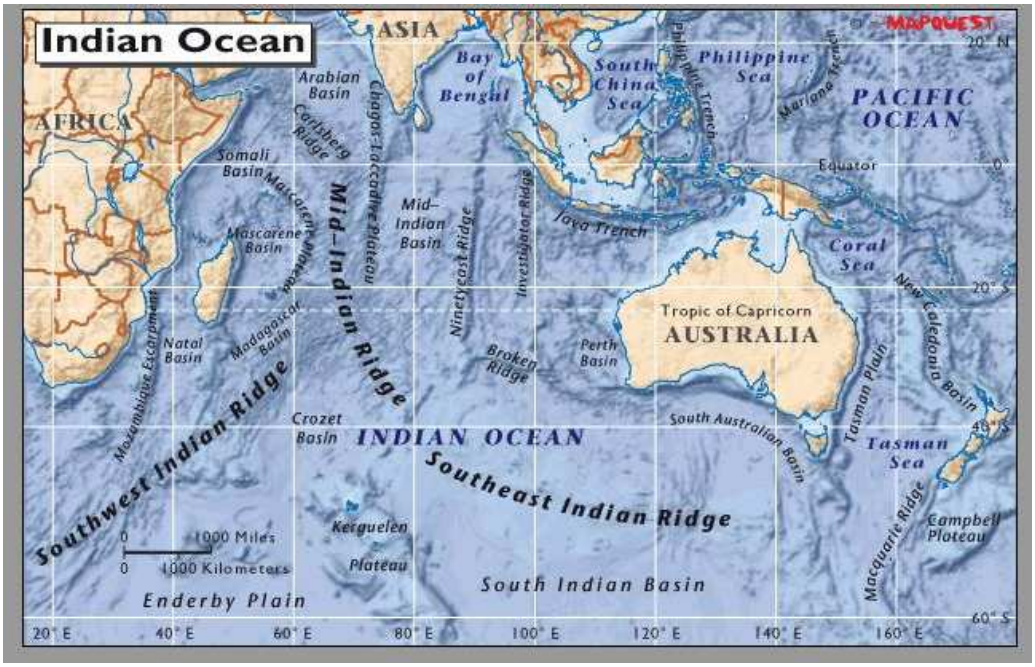


Fig.3.2d Different bottom features in Indian Ocean

Geologically, the Indian Ocean is unique among the other oceans of the world with the presence of several submarine plateaus, aseismic ridges and hotspots. Recent studies have revealed that the Indian Ocean floor is characterized by seismically active mid- Indian ocean

ridge system (Fig.3.2a & c) which marks the major boundaries separating the major plates. The northern branch of this ridge system includes east-west tending Sheba Ridge, the northwest – southeast tending Carlsberg Ridge between the Owen Fracture zone and the equator. The N-S tending central Indian Ridge (CIR) connects the southern end of the Carlsberg Ridge near the equator to the Rodriques Triple Junction (RTJ). At the RTJ, the central Indian Ridge joins the other two branches, ie, the southwest Indian Ridge (SWIR) and the Southeast Indian Ridge (SEIR). Apart from active mid-ocean ridge system, the Indian Ocean floor is also characterized by the large shallow areas scattered all over the ocean variously termed, according to their overall morphology as banks, plateaus, aseismic ridges, seamount chain and rises. Many of these features trend in a northsouth direction, and together with the active ridges and surrounding continents, the Indian Ocean is divided into a number of ocean basins. One of the outgrowths of these peculiar geological features is that the Indian Ocean has deep northward western boundary current.

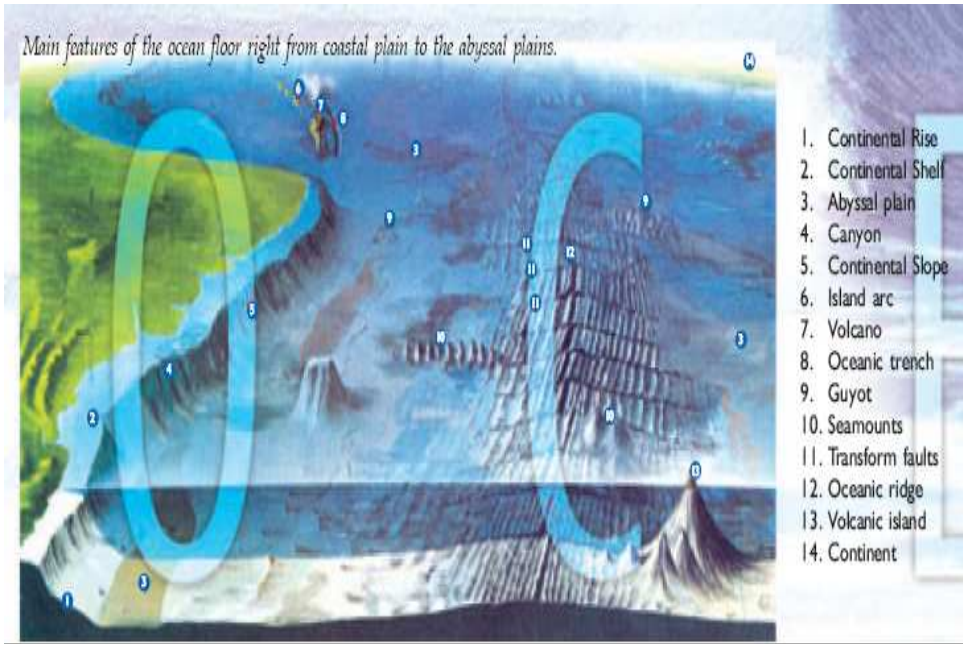


Fig.3.3 Different features of ocean floor

For most part of the ocean, sea-floor is dark as sunlight reaches only up to 200 meters from the sea surface. The water in the deep parts of oceans (about 1,000 meters) is very cold (only 2 to 4^0C)!

The bathymetry of north Indian Ocean is as shown in fig.3.4. The bottom topography is derived from the 5 ‘resolution ETOPO5’ data set supplied by the National Geophysical data center, USA.

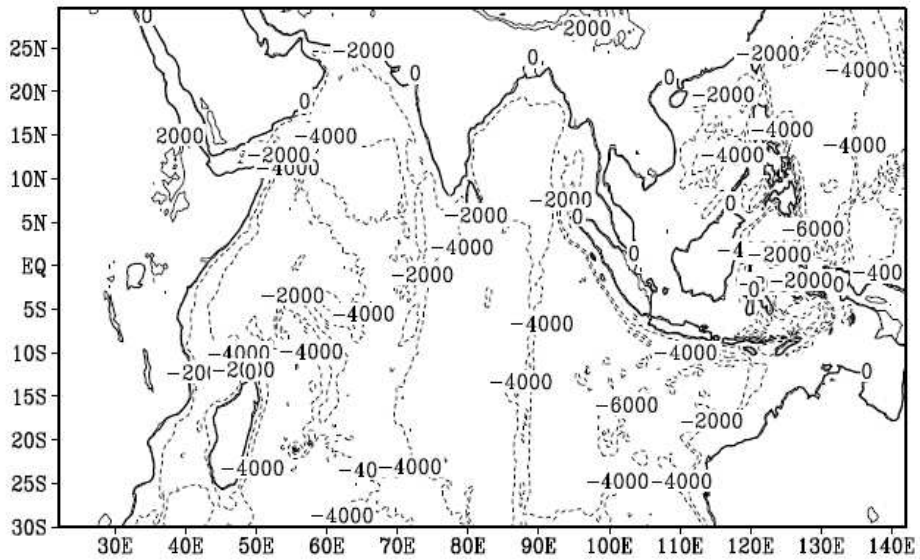


Fig.3.4. Bathymetry chart of North Indian Ocean as derived from ETOPO5 data set. Depths are in meters.

1.1.3. Divisions starting from land to oceans:

The littoral zone is the part of the ocean closest to the shore. The littoral zone is from the shoreline to 600 feet (183 meters) out into the water and is divided into three zones: the supralittoral zone, the intertidal zone and the sublittoral zone. The supralittoral, or spray, zone is only underwater during unusually high tides or during storms. It starts at the high-tide line and goes toward dry land. The intertidal zone is between the high-tide and low-tide lines. The sublittoral zone extends from the low-tide line out to 200 meters. The littoral zone is a tricky area for predicting water conditions because so many factors affect it. Coastal currents, onshore and offshore winds, reefs, bays and the shape of the shoreline are some of the things sailors have to deal with in this zone.

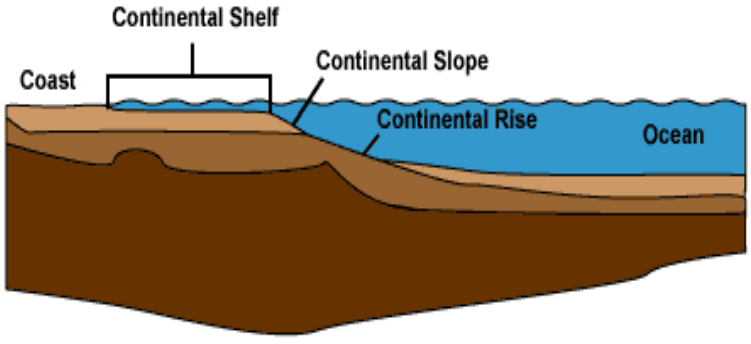


Fig.3. 5 a. Vertical cross section of the three dimensional view of the ocean

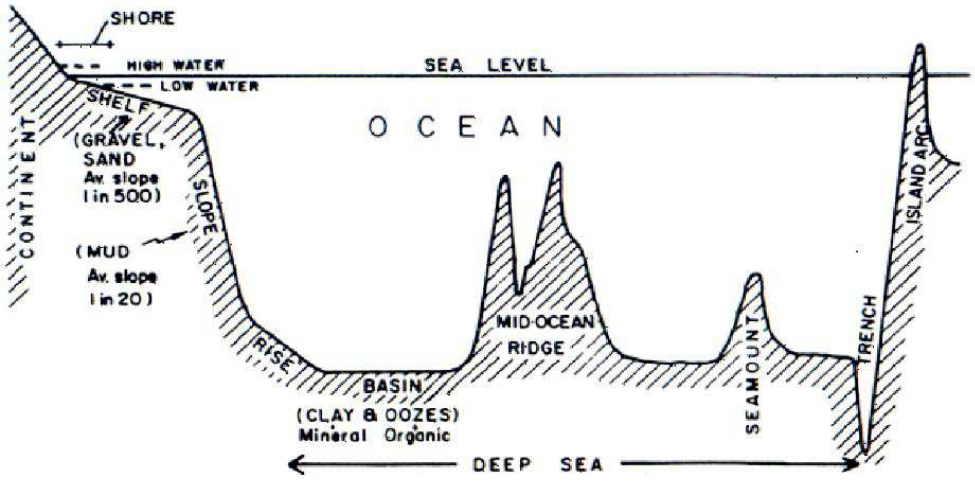


Fig.3. 5 b Divisions starting from land to ocean

The typical vertical dimension of the ocean profile is shown in Fig.3.5c. In this figure, the vertical scale has been exaggerated, to better illustrate the ocean's shape. Where the land meets the water, continents start with a gradual slope down to about 200m depth. It is called the continental shelf. For various reasons, this is the most productive part of the ocean. Beyond the continental shelf, the seafloor dips down more steeply (the continental slope) until it becomes more gradual again (the continental rise). Some continents are flanked by deep trenches. Where the continental rise ends (a vague boudary), the abyssal plane starts (Gk *a* = no; *bussos* = depth; *bottomless*). Where the ocean's floor is spreading, an ocean ridge is found, flanked by large fracture zones.

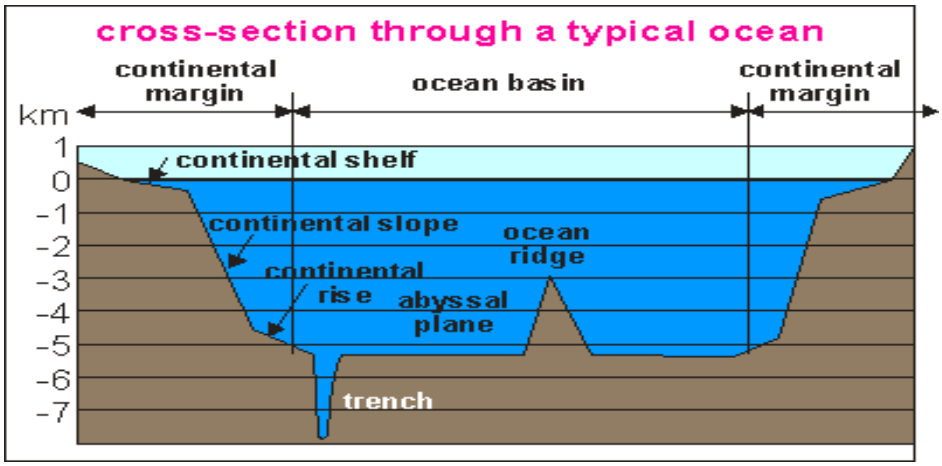


Fig. 3.5c. The typical vertical dimensions of the ocean floor

The continents form the major lateral boundaries to the oceans. Starting from the land, the main divisions recognized are the beach, the shore, the continental shelf, the continental slope and the abyssal plains (the deep sea bottom) as shown in Fig.3.5 a &b.

THE BEACH:

The beach is defined as the zone of unconsolidated sand material extending landward from the mean low water line to the place where there is a change in material or physiographic form such as the zone of permanent vegetation. The different parts of the beach terminology are shown in the figure 3.6a. The shore on the other hand is defined as that part of the land mass close to the sea which has been continuously modified by the action of the sea through swash and back washes.

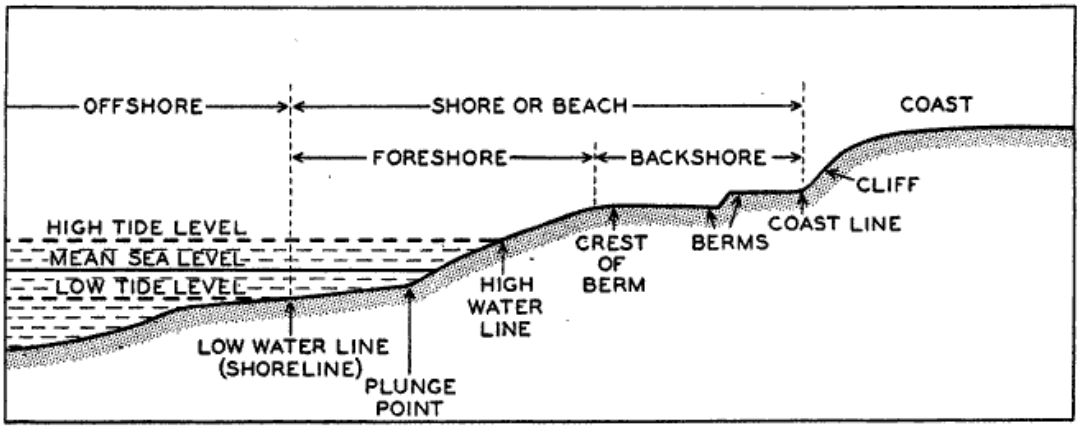


Fig.3.6a. Terminology applied to various parts of the beach profile.

Berms are small impermanent terraces which are formed by deposition during calm weather and by erosion during storms. The plunge point *is* the variable zone where the waves break; hence its location depends on the height of the waves and the stage of the tide.

Although subject to short-period disturbances, the beach in general represents an equilibrium condition, despite the slow erosion of the coast or the permanent deposition that may be taking place. If the normal interplay of waves and currents is disturbed by the building of piers, breakwaters, or jetties, the character of the beach may be entirely changed. In some instances, highly undesirable erosion of the coast may result, and in others equally undesirable deposition may result as in the case of Dhiga in west Bengal and Gopalpur Coast in Orissa and Visakhapatnam Coast in Andhra Pradesh along east coast of India in recent times.

Fig.3.6b Example of erosion in Gopalpur beach (orissa). Note the berm cut like a wall.

So the construction of breakwaters, jetties, sea walls or groins, and similar structures (as shown in Fig.3.6c) on an open coast should be undertaken only after a careful investigation of the character and source of the sedimentary material, the prevailing currents, the strength and direction of the waves, and other factors that determine the equilibrium of the beach.

Fig.3.6c Groins (rocks) kept for protection due to erosion and break water (bridge) for dredging the channel at Gopalpur Port (orissa)

The beach shown in the Fig.3.6d is typically found together with sand dunes. Not all beaches are like this. In the picture, the levels of high and low tide are shown and the wet beach is the area between them. The near shore zone extends to a depth of about 5m. In this zone much sand is moved because it is stirred easily by most waves. But the shore extends further down, to depths of 20m or more. At some time during a year or decade, the sand here is stirred by large storms and moved towards the beach. Going from the wet beach inland, one encounters the dry beach, outside reach of the waves, but high waves during spring tide may deposit sand here. This part of the beach is partly formed by wave overwash and by the wind heaping the sand up. It can even be considered a fore-fore dune. Further back from here extends the back shore with its fore, mid and rear dunes.

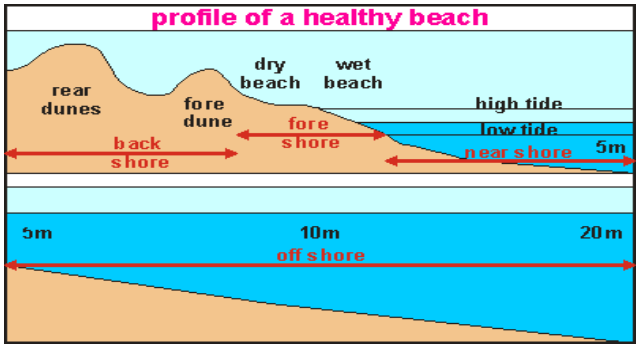


Fig.3.6d: Beach with sand dunes

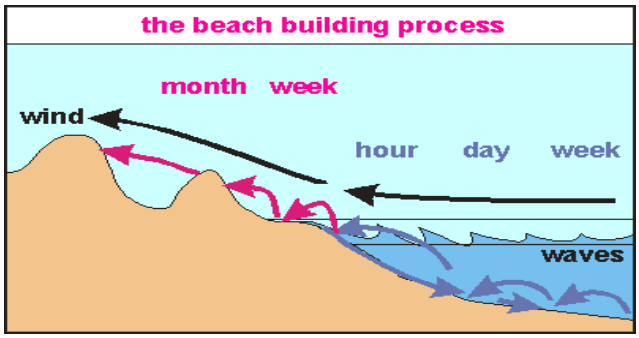


Fig.3.6e: Movement of sand on the beach

The Fig.3.6e shows how the sand moves in the water, on the beach and behind the beach. Large waves occasionally move sand towards the beach and when they do, they move large quantities. Closer to the beach the sand movement is an every day affair and in the breaker zone huge quantities are moved almost every hour. As waves move sand towards the beach, gravity and back-wash move it back again at the same rate. Most of the movements cancel each other out and by and large, the sand remains in place.

The big difference comes once the sand remains on the beach, dries out during the low tide and is removed by the sea wind. This sand can no longer be reached by normal waves. As the wind brushes over the dried beach, it pushes sand up-hill in a jumping motion (saltation). The sand grains of which dunes are made, are too large to blow like dust clouds in the wind but they can saltate rapidly like a moving sheet over the ground. Once particles fall into the lee (wind shade) of the fore-dune, they stay there, making it appear as if the dune rolls backward to the next dune and so on. In this manner sand is pumped out of the sea. It is the mechanism by which a beach can repair (rebuild) storm damage. The wind transportation is much slower than that of water and it may take weeks to repair the damage that a storm can do in one hour.

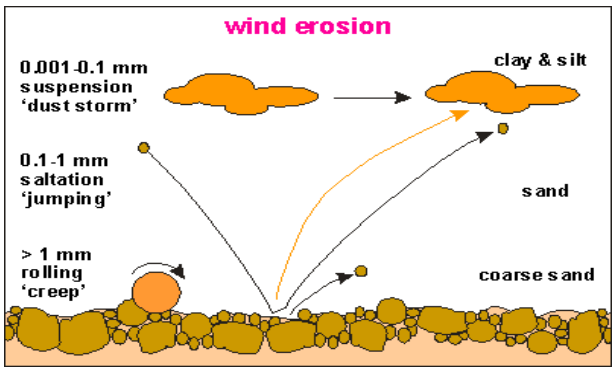


Fig.3.6f: Effect of wind on the beach

The Fig.3.6g shows how a beach reshapes itself during a storm and how it rebuilds afterwards again. In the top picture the dotted line shows the beach profile before the storm and the solid profile during the storm. The two horizontal lines in the water correspond to high and low tide, the normal extent of the wet beach. Storms not only arrive with higher waves, but also with a storm surge that lifts the water level. During high tide the waves attack the beach above its normal level. The fore-dune is carved out and its sand creates a new beach at the level of attack. Sometimes lower down a bank is formed, which helps to break the waves. The storm brings new sand but borrows sand from the dunes. After the storm (bottom picture), the forces of waves and wind gradually restore the damage wrought. Waves spread the increased amount of sand and sea winds gradually store it back onto the dunes where it came from.

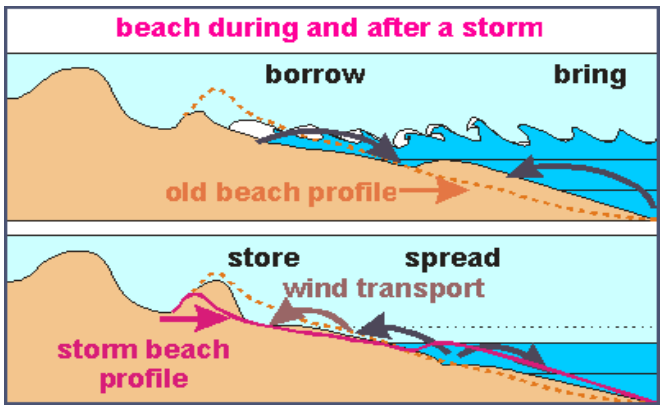


Fig. 3.6g: Effect of storm on the beach

The Continental shelf:

The Continental shelves are zones extending from the line of permanent immersion of sea water of the continent (or around an island) and extending from the low-water line to the depth, usually about 120 m, where there is a marked or rather steep descent toward great depths.

It extends sea ward from the shore with an average gradient of 1 in 500 (Fig.3.6). The continental shelf generally has an average width of 65 km but in some places like Chandipur and Rameswaram it can extends to 100 or 200 meters. The importance of the shelf is it is part of the continent and most of the world's fisheries are located here. The outer edge of the shelf in the oceans is found at a depth of 130 to 200 meters.

The Fig.3.7 shows the continental shelf and slope along the coastal boundary of Indian sub continent. The solid line is the 200 m isobath, which usually marks the shelf break, and the dashed line is the 1000m isobath. The shelf is narrow along the east coast of the Indian subcontinent, except in the northern Bay of Bengal. It is wider along the west coast, especially off Mumbai.

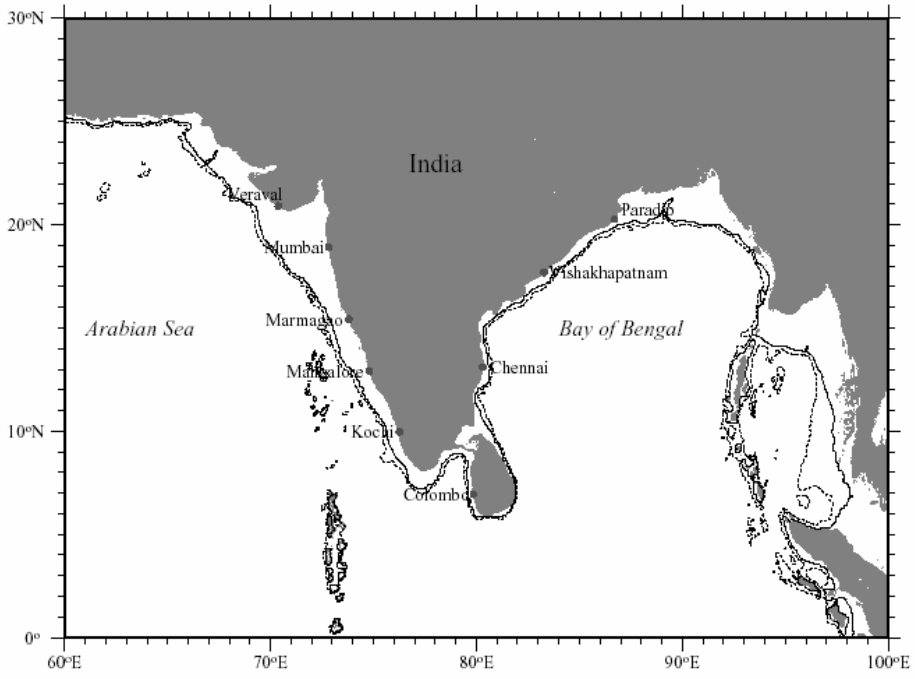


Fig.3.7. Continental shelf (200m-solid line) and slope (1000m –dotted line)of the Indian subcontinent

The Continental slope:

The Continental slopes are the declivities seaward from the shelf edge into greater depth. The very steep area in the offshore at the outer limit (break in slope) of the shelf where the gradient increases to about 1 in 20 is called the continental slope (Fig.3.6), which is often as narrow as 20 to 30 km in width and likely to drop at its outer edge to a depth of 2000 to 2500 meters.

The Continental Rise:

It is an area largely composed of continental sediment that has drained through the slope all through the ages and settled in the sea bottom. The Shelf, the Slope and the Rise together are called as the Continental Margin (Fig.3.5a &c).

The Bank:

It is more or less flat-topped elevation over which the depth of water is relatively small, but which is sufficient for surface navigation.

The Shoal:

It is a detached elevation with such depths that it is a danger to surface navigation and which is not composed of rock or coral.

The Reef:

It is a rocky or coral elevation (generally elongates) which is dangerous to surface navigation. It may extend above the surface.

A variety of names has been applied to the steep-walled fissures that penetrate the slope and cut across the shelf. The most commonly used terms are canyon and valley, but gully, gorge, and mock-valley are also applied to these features.

The Sill:

One another term used frequently in reference to bottom topography is the sill. It is applied to a submerged elevation separating two basins. The sill depth is the greatest depth at which there is free horizontal communication between the basins. This refers to a ridge, above the average bottom level in a region, which separates one basin from another or, in the case of a fjord, separates the landward basin from the sea outside. The sill depth is the depth from the sea surface to the deepest part of the ridge, i.e. the maximum depth at which direct flow across the sill is possible.

The Trench:

It is a long narrow depression with relatively steep sides in the mid ocean basin. The marginal deeps, to which the term trench or sometimes trough is applied, are the features within which the greatest depths are found, in nearly all cases exceeding 8000 m. Only one such trench is found in the Indian Ocean; namely, the Sunda Trench.

The Archipelago:

The conspicuous topographic features are the deep, partially isolated basins and the very wide shelf from which rise the large islands is called the Archipelago, for example, The Andamans and the Laccadive islands.

Ocean basins are deep depressions of the sea floor of more or less circular or oval form. Canyons are relatively narrow, deep furrows with steep slopes, cutting across the continental shelf and slope, with bottoms sloping continuously downward. Plains are very flat surfaces found in many deep ocean basins.

The mid-ocean ridge is two chains of mountains separated by a large depression (or rift valley) that form at a spreading center (or where two plates are drifting apart). The mountain ranges can have peaks as high as 2,500 meters and some even reach above the ocean's surface. Iceland, along the mid-Atlantic Ridge, is an example of this. In the rift valley, which can be 25 to 50 kilometers wide, new oceanic crust is being made, which means lots of seismic activity is happening. Hydrothermal vents were discovered in rift valleys. The plates are spreading at a rate of 2.5 centimeters a year. This means that every thousand years or so the plates spread and grow about 25 meters. Most seamounts began life as volcanoes formed over hot spots in the ocean floor. After the crust moves off the hot spot, the volcanic activity stops. Seamounts are usually 25 miles (40 kilometers) in diameter and can be 10,000 to 15,000 feet (3000 to 4500 meters) tall. In fact, some are so tall that their peaks pierce the ocean surface forming a volcanic island or, if there are more than one seamount, a volcanic island chain (think of the Hawaiian Islands). Seamounts whose peaks have eroded and become a flat surface are called guyots (Fig.3.3). Coral reefs sometimes grow around sea mounts that rise above the ocean waters. As the sea mount sinks or its peak erodes, the seamount will disappear beneath the water leaving the coral ring. This is called an atoll.

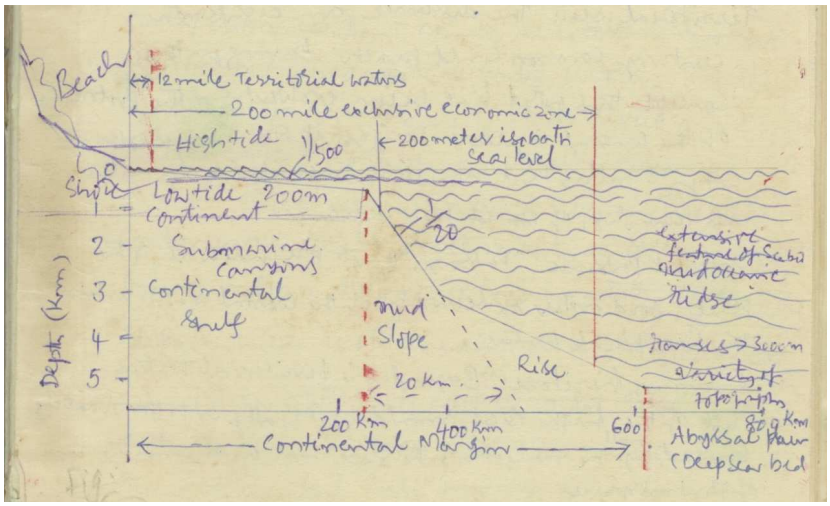


Fig.3. 8. slopes of shelf & slope

It is within this continental Margin (shelf, slope and rise together), that virtually the entire ocean's living and nonliving resources are lying. While the important non living organic resources like oil and natural gas are in the Continental Margin area, the manganese nodules containing nickel, copper and cobalt are in the deep sea bed. Apart from these resources, large placer deposits of 'rare earth minerals' like zircon, illimanite and Rutile are present on the beaches.

Because of the proper distribution of natural resources and to maintain peace due to border disputes between several oceanic countries and land locked countries a law of the sea has been formed. This law earlier mainly devised for rescuing a ship in the ocean and for exploitation of natural resources in the oceans. As there is a lot of disparity between the developed and under developed nations and the oceanic and land locked

nations for the exploitation of ocean resources this law mainly talks about three items. They are the territorial sea, the innocent passage and the common heritage.

LAW OF THE SEA

Who owns these resources and who can utilize them? The United Nations held three conferences (between 1967 and 1982) on this aspect and finally the United Nations Convention on the Law of the Sea was signed in 1982. The Convention laid down rules and regulations to rationally manage oceanic resources and conserve them for future generations. The oceans have been divided into several zones: Territorial sea (12 nautical miles (n.m.) from coastline), Exclusive Economic Zone (EEZ; 200 nautical miles from coastline; see Fig.3.9a & b), and the International Area of the Seabed (beyond the EEZ). Coastal nations have exclusive rights to explore and exploit all the resources within their respective EEZ's. Resources in the international area are a common heritage of mankind.

The United Nations Convention on the Law of the Sea (UNCLOS) that came into effect on 16 November 1994 provided for the first time a universal legal framework for the rational management of marine resources and their conservation. According to UNCLOS, oceans are divided into four domains:

1) Territorial Sea (coast to 12 nautical miles), where a country has exclusive right to exercise full sovereignty.

2) Contiguous zone (coast to 24 nautical miles), where a country can exercise regulations relating to immigration, customs, fiscal, sanitation.

3) Exclusive Economic Zone (coast to 200 nautical miles), where a country has the right to use both the living and nonliving resources in the water column, sea surface, and subsurface.

4) Legal Continental Shelf (coast to a maximum of 350 nautical miles), where country has the right to use only the non-living and sedentary resources (except water column) subject to satisfaction of certain geophysical conditions.

India, traditionally a seafaring country, has a wide EEZ (exclusive economic zone) of about 2 million sq km all along the 7500 km long coastline around her (Fig3.10). The living and nonliving resources in this exclusive economic zone of India constitute around two-thirds of the landmass of the country -Additionally, several million people living along the coastline are directly influenced by the oceanography of the EEZ, coastal environmental hazards, and related social issues. Our EEZ also boasts of many economically exploitable mineral and hydrocarbon resources.

Transportation, defense, and fishing are traditional uses of the ocean. But increasing demand for fuels, metals, and construction materials has in many instances outstripped the production capabilities of land resources and increasingly the ocean is being exploited to meet the need. This has been particularly obvious in the case of petroleum and natural gas, for which the EEZ is expected to become a prime source in the next few decades.

Managing sustained use of the resources of such a large area requires detailed knowledge and understanding of the very dynamics of the resource formation. Much of India also has several

groups of islands - the Lakshadweep group on the west and the Andaman group on the east. Unfortunately, there is not much data available about these islands.

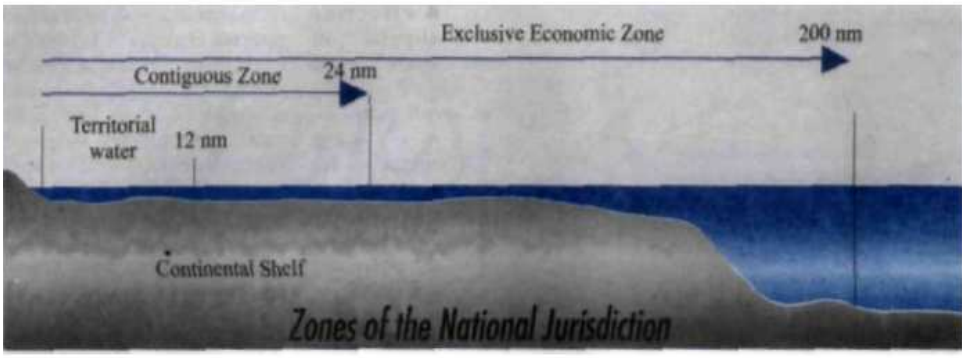


Fig.3.9a Description of the ocean features according to Law of the sea board

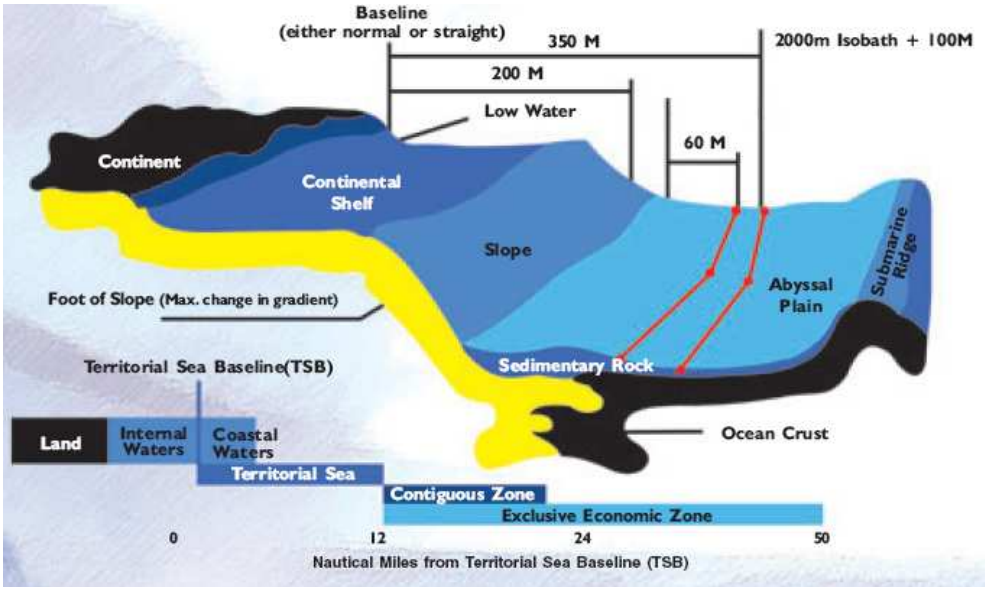


Fig.3.9b Description of the ocean features according to Law of the sea board

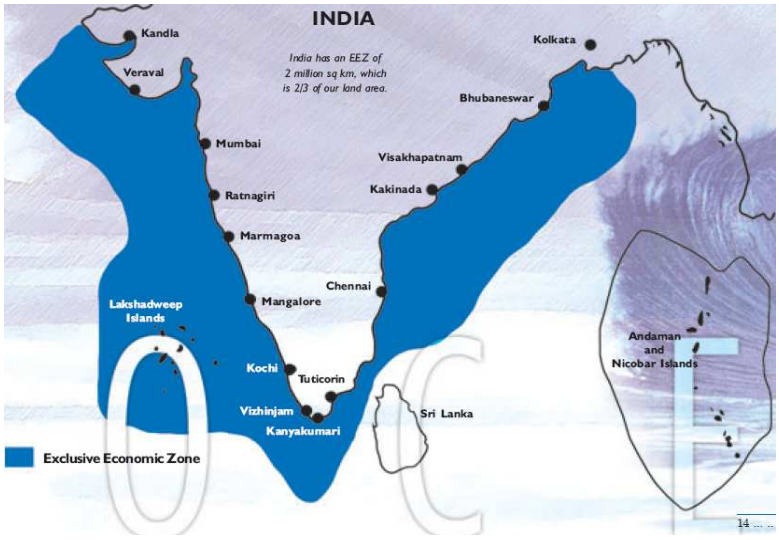


Fig.3. 10 The area of coverage (2×10^6 Km^2) of Exclusive Economic Zone of India

The Figure 3.10 shows the area of exclusive economic zone of India which has 2×10^6 Km^2 that comes to about two thirds of the land area of India.

The Territorial Sea:

It is defined as the distance an eighteenth century common man could reach from his beach. This concept was evolved at that time to show that this area is that part of the country and it has all the rights and other foreigners can not enter into this area of the ocean without the permission. Thus it was evolved for the self protection of a coastal nation. Its extent from the beach is 12 nautical miles. Later recently another 200 nautical miles added as an exclusive economic zone only for exploitation of natural resources

The Innocent Passage:

This is introduced in the law for the protection of a traveling ship who is in distress. By giving a distress signal any foreign vessel can enter into the territorial waters of a nation. This is referred to as the innocent passage. That means this passage is not prejudicial to the peace, good order and security of the coastal nation.

The Common Heritage:

This word is introduced for the benefit of the land locked countries that do not have a chance to use the ocean's wealth for natural resources, communication, navigation etc. Just as the air and water are everybody's property, Ocean also should be every body's property. Hence beyond the territorial waters any nation can go and exploit natural resources or use the oceans for any kind of purpose like making a defense colony or a naval base.

COASTAL REGULATION ZONE (CRZ) NOTIFICATION

INDIA'S POLICY FOR PROTECTING THE COASTAL ENVIRONMENT FOR SUSTAINABLE USE:

In recent years, the country's coastal stretches have become a pressure point for indiscriminate and unsustainable development pressures. The coastal zone – the land which extends from the beginning of the coastal plain to the beginning of the continental shelf - occupies only a marginal portion of the country's territory yet it is home to a disproportionately large section of the population. And the numbers are ever on the increase. It is not only the powerful scenic beauty that this eco-region has to offer which drives people to crowd themselves in these narrow stretches, but the fact that the coastal regions are extremely productive lands hosting nearly a quarter of the earth's primary plant production, the world's major spawning grounds and fish nurseries and also some of the most fertile agricultural lands.

In addition to farming and fishing - the two major coastal industries - there are several development interests which also show a marked preference for the coastal region. Industries wish to be located there for easy access to the sea for discharge of effluents; thermal power plants, for easy access to the enormous quantities of cooling water they need; tourism promoters want to use the beaches for raising hotels; middle- and upper-class citizens wish to have residential bungalows located there. There are also activities for which foreshore facilities are essential: for example, ports, harbours, jetties, wharves and quays. All these new development pressures are in addition to demands already being made by existing coastal inhabitants. The concentration of development activities on such a scale, in fact, threatens to destabilize the very resources that provide the possibilities of living in the coastal belt. The increased economic activities in the region over the past three to four decades have led to the depletion of marine life due to over fishing in coastal waters, the leveling of sand dunes (nature's first line of defense to protect the hinterland from the ravages of the ocean), the destruction of hundreds of acres of mangrove forests and coral reefs, and the ingress of saline water into adjacent freshwater aquifers. In addition, pollutants and toxins galore are emptied daily into the coastal waters as the authorities find it a cheap and easy way to get rid of town and industrial wastes. In India, these pressures would have led to a sharp decline in both the aesthetic and the ecosystem values of such areas and would also have impinged negatively on traditionally sustainable economic activities carried out by fishermen and toddy tapers. It is also widely known that tourism development in several other parts of the world has led to closure of beaches to the local population as the tourism promoters have increasingly privatized these hitherto public resources. Cramming such areas with large numbers of buildings for tourists has also reduced their tourism value, dissuading people from visiting.

The CRZ Notification issued in 1991 by the Ministry of Environment and Forests seeks to tackle some of these issues and to place any further proposed development within India's vast coastal stretches within a controlled framework. The Ministry of Environment and Forests, Government of India, has created a statutory innovation in the form of a legal notification for the protection and planned development of coastal areas,

including the reservation of areas in coastal zones set aside as No- Development Zones. The notification actually crystallises a fairly firm policy that had extended over a decade to protect coastal areas from unplanned and indiscriminate human activities. ***On 19 February 1991,*** the Ministry of Environment and Forests issued an elaborate notification called the Coastal Regulation Zone (CRZ) Notification which sought to regulate human activities in the area of 500 m from the High Tide Line (HTL) along the coastal stretches of the country. The CRZ Notification came into immediate effect on the same day and was made applicable to the entire 6,000 km coastal belt of India and, in addition, to riverine stretches affected by tidal action. The objective of the CRZ Notification is to protect the coastal areas from becoming degraded due to unplanned and/or excessive development which results in pollution and the eventual destruction of this highly prized, fragile and irreplaceable natural resource. The Notification is a unique piece of statutory regulation and other countries that seek to also regulate activities in their coastal areas for environmental reasons may benefit from studying India's experiences.

DESCRIPTION OF THE PRACTICE/INNOVATIVE EXPERIENCE AND ITS MAIN FEATURES

The statutory innovation is today referred to as the CRZ Notification. ***It was issued under the powers given to the Central Government under the Environment Protection Act 1986.***

The Environment Protection Act itself is a comprehensive piece of legislation which has become today the basis of environmental law in the country and an enormously powerful legal tool for environmental protection. The CRZ Notification was issued on 19 February 1991 and is decidedly one of the most controversial and significant statutes to be issued under empowering clauses of the EPA. Under the CRZ Notification, the coastal stretches of seas, bays, estuaries, creeks, rivers and backwaters which are influenced by tidal action (in the landward side) up to 500 m from the High Tide Line (HTL), and the land between the Low Tide Line (LTL) and the HTL, were identified as the Coastal Regulation Zone (CRZ). Areas identified as CRZ would henceforth receive special and individual protection. The Notification forthwith imposed several restrictions on the setting up and expansion of industries, operations and processes in these areas. Among the activities that are today prohibited outright in CRZ. Areas are the following:

- setting up of new industries and expansion of existing ones;
- manufacture, handling, storage or disposal of hazardous substances;
- discharge of untreated waste and effluents from industries, cities, towns
- and other human settlements;
- land reclamation, bunding or disturbing the natural course of sea water;
- mining of sand, rocks and other substrata minerals:
- drawing of groundwater, using mechanical means; and
- dressing or altering of sand dunes, hills and other natural features, including landscape changes, for beautification, recreation, etc.

All activities other than those expressly prohibited are sought to be strictly regulated in the CRZ and henceforth require the prior approval of the Government of India (especially if the investment exceeds five crores (50 million) of rupees). The Government itself, moreover, cannot grant approvals for projects in contravention of any of the restrictions imposed on coastal areas by the CRZ Notification.

For purposes of proper planning and management of the coastal areas, the CRZ Notification classifies coastal areas into four zones depending on the intensity of protection that these areas require and also considering the extent of development that has already taken place in such areas. The four zones are as follows:

(a) CRZ I: Comprises those areas that are most fragile and consequently in need of absolute protection from any form of development. The zone therefore comprises areas which are ecologically sensitive and vulnerable, such as mangroves, coral reefs, national parks, marine parks, sanctuaries, spawning grounds of fish and other marine life, areas rich in genetic diversity, areas of outstanding natural beauty, historical and heritage areas, areas likely to be inundated due to global warming and the foreshore area which lies between the LTL and the HTL. In this zone, for obvious reasons, no development whatsoever is permitted by the statute.

(b) CRZ II: Comprises areas that have already been developed up to or close to the shore line. All cities and other well-populated areas which are substantially built up and have roads and other infrastructural facilities such as water supply and sewerage mains would fall into this zone. In these areas, development is permitted only on the landward side of existing buildings or roads -the general idea being that since it is not economically and politically feasible to reverse the development that has already taken place, the least one can do is to prevent further damage by restricting development to areas behind those that have already been developed. Since, by and large, in most of the coastal metropolises high-rise buildings already exist up to the waterfront, and paved roads and footpaths cover the rest of the open areas, not much additional development can actually take place in new areas or areas not yet touched by development except in areas where construction already exists. (c) CRZ III includes those areas that are relatively undisturbed and which do not fall under either CRZ I or CRZ II. This includes largely rural areas and also areas in legally designated urban areas which are not substantially built up.

(c) CRZ III zones: the area up to 200 m from the HTL is a No-Development Zone and no construction/development is permitted in this stretch. Between 200 m-500 m, a concession has been made for the foreign-exchange earning potential of the tourism industry and therefore hotels for tourism purposes are permitted, provided they comply with certain conditions. Among the conditions listed are the following:

i. the hotel or resort buildings will not have more than two floors (ground plus one upper floor) and the total height of construction will not exceed 9 m up to the highest ridge of the roof;
ii. groundwater will not be tapped by mechanical means in the area up to 500 m from the HTL;
iii. there will be no extraction of sand or leveling of the sand dunes;
iv. the floor space index will not exceed 33%**;**
v. any green fencing or barbed-wire fencing that is put up within 200 m of the HTL will not hamper public access to the beach; and
vi. the construction will be consistent with the surrounding landscape and local architectural style.

Recognizing that the beach areas are an important arena **of** economic activity for the coastal communities comprising fisher folk, and recognizing also that beach areas form a valued recreational area for the vast majority of common folk, the Environment Ministry also gave much weightage to the question of public access to the beach. The law

therefore stipulates that "to allow public access to the beach at least a gap of 20 m width shall be provided between any two hotels/beach resorts and in no case shall gaps be less than 500 m apart." This implies that: (i) hotels adjacent to each other must have an access for the public to the beach between them, and (ii) if the beachfront property owned by a hotel is a very large one, there must be a public access which cuts through the property every half a kilometer.

(d) CRZ IV: The zone comprises the coastal stretches of the Andaman and Nicobar Islands, Lakswadeep and other small islands. These eco-fragile regions have been treated as separate entities and special protection status has been accorded to them as a consequence. Under the Notification, the coastal states **of** the Indian union have been directed to prepare Coastal Zone Management Plans (CZMPs) which will identify the CRZ areas in each state, classify them into zones in accordance with the Notification and also indicate the scope of development planned or proposed therein. The different CZMPs of the various coastal states were prepared under the specific direction of the Indian Supreme Court in 1996 and were also approved in the same year by the Ministry of Environment and Forests. They now control or provide the framework for the sustainable development of India's coastal areas.

The CRZ Notification of 1991 was in fact the culmination of a decade long period of intense activity on the part of the Government of India to protect the coastal areas from being ravaged and destroyed by the forces of unplanned development. Thus, the coastal areas first received executive protection way back in 1981 when the then Prime Minister Mrs. Indira Gandhi – a world-renowned figure known for the environmental causes she championed - addressed a brief letter to the chief ministers of all the coastal states in India directing them to ensure that the coastal zone up to 500 m from the HTL was kept free from development activities of all kinds. This straightforward and simple communication - though technically bereft of legal sanction as it did not emanate from Parliament - was nonetheless widely respected as a diktat issuing from the ruling head of government and consequently observed and obeyed. The period from 1981 to 1991 saw guidelines being issued in line with the policy as well as some modifications and changes in the implementation of the same guidelines. During this period, there was also intense activity on the part of NGOs to lobby the government to give the policy legal backing. Eventually, when the Central Government decided to come up with legal protection, several NGOs were associated with the preparation of the Notification. The draft notification was next gazetted for objections. After these were all considered, the necessary changes were effected in the draft notification. Finally, in February 1991, the CRZ Notification became the new statute applicable to all coastal areas, protecting this natural resource for the present and future generations of this country.

DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS

The Ministry of Environment and Forests which is the institution responsible for drafting and issuing the CRZ Notification, was set up by the Government of India in the early 1980s. It is a normal government ministry headed by a Minister with independent charge. (Prior to that, it functioned as a department.) Since 1981, the Ministry's scientists had been working on a set of guidelines for the protection and development of coastal areas. Several meetings were organized by the Ministry with experts, NGOs and

environmentalists to expand the fund of knowledge and expertise available in the Ministry on the coastal ecosystems.

Finally, a set of detailed guidelines was drawn up and published in the form of a booklet and circulated to all coastal states. Thereafter, the Ministry has continued to administer the Notification. Since the Ministry is subject to intense political pressures, it has been forced at times to try and water down the coastal regulations. However, such efforts have not been successful in the past due to the vigilance exercised by NGOs.

PROBLEMS OR OBSTACLES ENCOUNTERED AND HOW THEY WERE OVERCOME

There have been several problems encountered in the entire exercise of enforcing the CRZ Notification. Most of these have resulted from pressures exerted by vested interests and development bodies who would like to have greater liberty in utilizing the resources of the coastal areas for their own short-term private objectives. The tourism lobby was the most vocal of the lot and did everything in its power to sabotage the Notification once it was issued, either by flouting it openly **or** by undermining it surreptitiously. Thus, violations of the law cropped up almost immediately after the statute was notified. Disputes were raised by resort developers about the location of the HTL, constructions were surreptitiously raised in the 200 m No-Development Zone, groundwater was illegally tapped by digging bore and tube wells, and resort owners attempted to enclose the open spaces in the No-Development Zone with fencing or walls. It was at this juncture that Indian environment NGOs promptly stepped in. They first registered their protest against such violations with the government and when they found that that was not enough, they approached the courts. Writ petitions were filed in the courts challenging the violations of the CRZ Notification as being violative not only of the EPA but also of Art. 21 of the Indian Constitution (Art. 21 enshrines the right to life: the Supreme Court of India has taken the stand that Art. 21 now includes the right to a safe, clean and healthy environment. Thus, all courts in the country are bound to take cognisance of environment offences.).

Responding positively and often swiftly to these writ petitions filed in the public interest, the judiciary made several observations which served to strengthen the CRZ Notification. It held, for example, that the No-Development coastal zone was absolute and sacrosanct and no development whatsoever could be permitted therein. In some cases, it ordered the immediate removal of illegal structures constructed in the No-Development Zone. In others, it halted construction work midway when it was shown that the construction activity was destroying the sand dunes. The courts were equally severe when instances of illegal tapping of groundwater in the coastal areas by five-star luxury-resort owners were brought to their notice: they ordered the immediate closure of such illegal wells. The issue of public access to the beach also found favour with the courts and they were quick to protect the public interest by ordering the removal of unauthorized walls and fencing, thus reopening the traditional pathways. The result of the fight put up by the environment NGOs and public-spirited citizens to save and protect the coastal areas and the positive response of the judiciary drove home the message that the law would be strictly enforced and violators strictly dealt with. The judicial orders also served to give the CRZ Notification all the judicial sanction it required. Faced with this situation, the tourism and development lobby did the next best thing. It prevailed upon

the Environment Ministry to modify and relax the CRZ Notification. This was done by the Environment Ministry in August 1994; an amendment Notification was issued under which some of the more stringent conditions of the original 1991 Notification were relaxed. However, most of these modifications - the principal objective of which was to ensure that the **CRZ** Notification became a worthless statute – were struck down by the Supreme Court and the original provisions restored. Another obstacle to implementation of the CRZ Notification was the attitude of the state governments, which resented interference by the federal government in what they saw as their territorial fiefdoms. Some of them also tried to back CRZ violators by applying their own interpretations on the CRZ Notification. For example, the state of Goa demarcated the HTL based on maritime data which resulted in the HTL being marked far closer to the sea than was permissible. Naturally, if the coastal zone shifted 40 to 50 m closer to the sea, there would be obvious advantages for developers and industrialists. The Goa government also attempted to demarcate practically the whole of Goa as CRZ **II** (the zone which allows maximum development) and to exclude the riverine areas from the purview of the CRZ Notification. State governments were also lackadaisical in the preparation of the Coastal Zone Management Plans and delayed them as far as they could. It was only with the intervention of the Supreme Court that all the coastal states prepared their CZMPs by 1996.

Once again, it was the NGOs which played an important role in ensuring that the CZMPs were prepared strictly in accordance with the Notification and would not turn out to be mere pieces of paper incapable of really protecting the coastal areas. On becoming aware that mischief was afoot in the process of finalising the CZMPs in some states, environment NGOs launched a fierce counter-attack. They prepared their own CZMPs with detailed explanations and sent them to the Environment Ministry, which was in charge of approving CZMPs, so that the Ministry would be well prepared to evaluate the CZMPs submitted by the coastal states. The Central Government thereafter was forced to send its own team of experts to countercheck the CZMPs produced by the states. Thus, the perpetration of a fraud on the public was prevented and the objectives of the CRZ Notification maintained. It is thus the vigilance of environment NGOs and concerned citizens which has forced the authorities to enforce the CRZ Notification and the statutory coastal management plans. However, the main problem in the implementation of the Notification still remains -namely the lack of political will on the part of the coastal states. Pressures continue to be exerted on the Central Government **to** consider yet another round of amendments to the CRZ Notification on grounds of economic development and because the Notification is alleged to be causing hardship to the common people. The protagonists of this move have sought to play on the feelings of ordinary people, particularly the fishing community, by depicting the CRZ Notification as an anti-people law in as much as it restricts development in the coastal areas. This is actually not true because the CRZ Notification specifically permits the traditional inhabitants of the area, namely the farmers and fisherfolk, to construct or renovate their dwellings within the CRZ while restricting outsiders from doing so**.** For a while, people were swayed by such canards and showed signs of resisting the CRZ Notification. But not continued for long anymore. Uneducated and generally marginalised, they have seen how big business, industrial development and tourism have displaced them from their traditional occupations without giving them alternative sources of employment. The

traditional fishing communities all along the west and east coasts of India have now rallied solidly behind the CRZ Notification.

EFFECTS OF THE PRACTICE/INNOVATIVE EXPERIENCE

The CRZ Notification has turned the coastal areas into a major battleground, with those who see them as an arena for unlimited opportunity on one side and those who argue for restraint in the interests of ultimate survival and protection of the region on the other. However, the necessity of implementing the Notification underlined recently by a comprehensive Supreme Court judgement has led to enhanced appreciation of the coastal environment, coastal ecosystem values and long term sustainable development practices. The large-scale pressure groups and lobbies that had hoped to impose themselves in CRZ areas in the 1980s have now found themselves largely restrained due to the limitations set by the Notification. Town planning authorities have been forced to think of alternative measures to dispose of coastal town wastes since the CRZ Notification has declared it illegal for the authorities to continue to use the oceans as dumping grounds for untreated wastes and effluents from industries, towns or cities and other human settlements. Shrimp aquaculture (prawn farming) in the coastal areas has also suffered a setback, with the Supreme Court declaring intensive and semi-intensive forms of prawn farming contrary to the Notification. This form of aquaculture, besides displacing the traditional rice/shrimp rotating aquaculture practiced by the local farming community, had also begun to pose a serious threat to the environment due to coastal pollution as effluents from the aquaculture farms were being discharged directly into coastal waters without any treatment. Chemicals and antibiotics injected into the feed to produce high yields of shrimp eventually find their way into the fragile coastal belt, threatening other fragile forms of marine life. Even the pressure to raise large-scale residential complexes has declined with the restriction that only those from the traditional coastal village communities can construct residential houses and that too after obtaining the required permissions. The 200 m zone (from the HTL) has continued to remain largely a No-Development Zone and this has resulted in many of the coastal areas being maintained in their original natural state. This itself is an attraction for tourists who have long tried to escape from the concrete jungles of their own countries. More importantly, it is protective of traditional livelihoods like fishing and toddy-tapping. Thus, in contrast to tourism development in countries like Spain or Malaysia, the coastal areas in India and their specific ecological endowments have been left largely intact and in their wild and natural state. India has conceded that nature also has its own right to be.

POSSIBILITY AND SCOPE OF TRANSFERING TO OTHER COMMUNITIES OR COUNTRIES

Several aspects of the CRZ Notification and its features could be utilized by other statutory authorities in other coastal countries for implementation under their own statutory laws. The CRZ Notification should be studied by the Environment Departments of other countries in the South. It will certainly be **a** useful model for them, even if they do not need to copy all its features in planning for the sustainable development of their own coastal areas.

OTHER COMMENTS

Literature on the CRZ Notification is easily available in India in printed form. An excellent compilation is available from The Goa Foundation, Above Mapusa Clinic, Mapusa 403 507, Goa, India. The book contains the CRZ Notification, the Supreme Court judgement upholding it and the approved **CZMPs** of all the coastal states in India.